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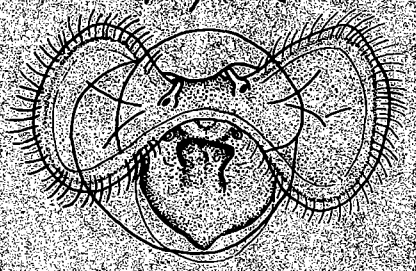

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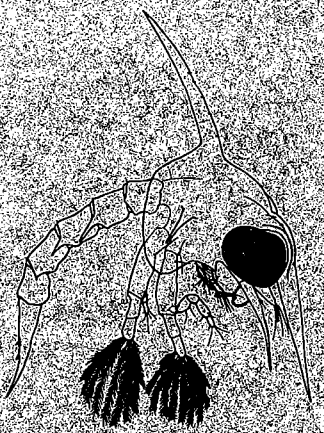
Woods Hole Oceanographic Institution

Development and Planktonic Larvae of Common Benthic Invertebrates of the Woods Hole Massachusetts Region:

Summary of existing data and bibliographic sources

by

Rudolf S. Scheltema



April 1984

Technical Report

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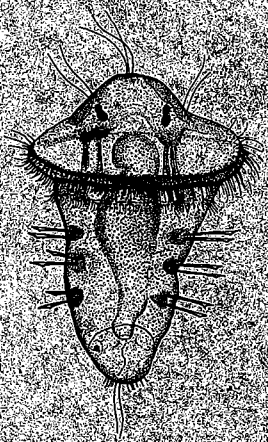

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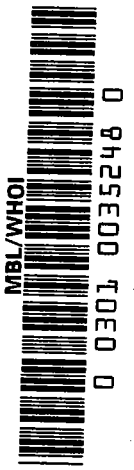
DEVELOPMENT AND PLANKTONIC LARVAE OF COMMON BENTHIC INVERTEBRATES OF THE WOODS HOLE, MASSACHUSETTS REGION:

Summary of existing data and bibliographic sources



by

Rudolf S. Scheltema

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

April 1984

TECHNICAL REPORT

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Approved for distribution:

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FOREWORD

Coastal Research Center

Technical Report Series: Buzzards Bay

The Coastal Research Center of the Woods Hole Oceanographic Institution has initiated a series of WHOI/CRC Technical Reports in order to make information generated by CRC-associated researchers available as rapidly as possible to the coastal community.

Buzzards Bay is an important segment of the Massachusetts coast and has been studied by the Woods Hole scientists and others for decades. However, only a few systematic studies have been completed. Increasing development pressure in this heavily used area has been followed by an increasing demand for more complete information on coastal environmental quality. In an effort to fill this information gap, and to foster understanding of fundamental processes operative in coastal areas in general, Coastal Research Center scientists are pursuing multi-disciplinary research in Buzzards Bay. As the results of this become available, this information will be published in the CRC Technical Report Series.

TABLE OF CONTENTS

EXISTING DATA ON LIFE HISTORIES OF BENTHIC INVERTEBRATE SPECIES

The early life histories of more than one-half of the most common benthic invertebrates from the region of Woods Hole, Massachusetts have not been described (Table 1). In many instances it has not even been determined whether or not the development of a species includes a planktonic stage (Table 2). Larvae taken from the plankton often cannot be identified to species or even to genus because descriptions of their morphology do not exist; those descriptions that do exist are widely scattered in the biological literature.

The extent of information that is available for the identification of larval forms is tabulated here for the most common species within the major benthic taxa in the Woods Hole region: gastropods (Table 3), bivalve mollusks (Table 4), decapod and stomatopod crustaceans (Table 5), cirriped crustaceans (Table 6), polychaete annelids (Table 7), and echinoderms (Table 8).[1] (Not included are amphipods and isopods, and other peracarid crustacea, which do not have planktonic larval stages.) Taken as an arbitrary criterion for the designation "common species" is inclusion in the KEY TO MARINE INVERTEBRATES OF THE WOODS HOLE REGION (edited by Smith, 1964, designated hereinafter as the "KEY"). To the list of species found in the KEY have been added a few that were obviously overlooked; those few species designated rare in the KEY have been deleted. By the criterion used, there are, within the taxa designated above, a total of 380 species. This figure must be considerably less than the actual number of species. Summer et al. (1911) in the CATALOGUE OF THE MARINE FAUNA OF WOODS HOLE AND VICINITY listed 444 species within the taxa considered here. Since 1911, sixty-four additional polychaetes are known from the region, and the forty-eight species of gastropods listed in the KEY represent only a fraction of all known prosobranchs. A recent unpublished checklist by R. D. Turner (Museum of Comparative Zoology, Harvard University) includes 228 species, but this list is

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[1]Readers finding omissions are urged to refer them to the author so that they may be added to any future compilation.

Table 1. Estimated percentage of common invertebrate species in the Woods Hole, Massachusetts region whose planktonic larvae are undescribed[1]

Taxon	Total no. common species	No. species known to have planktonic larvae	Total no. species estimated to have planktonic larvae[2]	No. larval species species described[3]	Estimated percent of undescribed planktonic larvae
GASTROPODA	48	28	36	11	69
BIVALVIA	52	40	40	28	30
DECAPODA	36	36	36	21	42
STOMATOPODA	2	2	2	1	50
CIRRIPEDIA	8	8	8	8	0
POLYCHAETA	221	50	166	20	88
ECHINODERMATA	13	9	10	7[4]	30
	380	173	298	96	68

[1]Common species are arbitrarily defined as those appearing in **KEY TO MARINE INVERTEBRATES OF THE WOODS HOLE REGION**, R. I. Smith (ed.), Contr. No. 22, Systematics Ecology Program, Marine Biological Laboratory, Woods Hole, MA. x + 208 pp.

[2]Seventy-five percent of species (except Crustacea) are assumed to have planktonic larvae.

[3]Only descriptions of larvae from laboratory culture are regarded adequate for use in identification.

[4]This number is inflated insofar as illustrations useful for identification of larvae from plankton.

based on a larger area and includes species to the edge of the continental shelf. Although many uncommon or rarely encountered species are not included in the tables, the life history of an unlisted form is not likely to be known. If uncommon species were added to the list, obviously the proportion for which life history observations are unavailable would be even larger.

Appended is a bibliography upon which Tables 3-8 are based (**APPENDIX I**). About one-third of the literature cited will not be adequate actually to identify larvae from the plankton and will only provide a basis upon which further life history studies may proceed. The scientific names used in the tables are those given in the **KEY** in order to avoid confusion; in some instances, currently used names have been added in brackets.

REMARKS ON THE NEED FOR LIFE HISTORY DATA AND DESCRIPTIONS OF LARVAE OF BENTHIC INVERTEBRATES

Sanders (1960) studied "the structure of the soft-bottom community" at a single location ("Station R") in Buzzards Bay near Woods Hole and listed 79 species of benthic invertebrates in rank order according to abundance. Among the first ten most abundant species (94% of all individuals) the life history of only three were known (viz., 2 bivalves, one imperfectly, and one crustacean). The life history of the remaining seven species of polychaetes and gastropods still remain unknown. A similar state of affairs exists for most regions along the Atlantic coast of North America.

Few keys are available for the identification of larvae. For the temperate East coast of the United States there are only those of Thiriot-Quievreux (1983) for gastropods of the Beaufort region, and the "AID TO IDENTIFICATION" (not a key) for the common bivalves of Virginia (Chanley and Andrews, 1971); both are based largely on shell characteristics, but the bivalve descriptions do not include hinge characters important for the identification of bivalve larvae. There is also a key to barnacle larvae of the Carolinas by Lang (1979).

Table 2. Mode of development of common benthic invertebrate species from the Woods Hole, Massachusetts region[1]

Taxon[2]	Total no. common species	Mode of Development			
		Non-planktonic	Planktonic	Unknown	% Unknown
GASTROPODA[3]	48	11	28	9	19
BIVALVIA	52	6	40	7	13
POLYCHAETA	221	8[4]	50[5]	163	73
ECHINODERMATA	13	3	9	1	8
	334	28	127	180	54

[1]Common species are arbitrarily defined as those appearing in **KEY TO MARINE INVERTEBRATES OF THE WOODS HOLE REGION**, R. I. Smith (ed.), Contr. No. 22, Systematics Ecology Program, Marine Biological Laboratory, Woods Hole, MA. x + 208 pp.

[2]Decapoda, Stomatopoda and Cirripedia are not included, since all known temperate species in these taxa have planktonic larvae.

[3]Excluded are shell-less Ophisthobranchia.

[4]Includes lecithotrophic demersal and brooded larvae.

[5]Includes lecithotrophic planktonic larvae and species reported to be poecilogonous.

Thorson (1946) considered the relationship between planktonic larvae and bottom populations and concluded that "stocks of such invertebrates as have a non-pelagic or a shortened lecithotrophic development show only slight variations in weight from year to year, while stocks of invertebrates which have planktotrophic larvae with a long pelagic life may be subject to very great fluctuations." Now, almost 40 years later, the precise significance of planktonic larval development to recruitment, population size, and species composition of bottom communities is still largely unknown.

Thorson (1966) subsequently suggested that fluctuations of bottom populations might be related to (a) differences in larval survival from one year to the next, (b) interactions of larvae and resident adults at settlement and (c) differences in mortality of recently settled postlarvae. The evidence to support or refute any of these hypotheses is still meager for most bottom communities (see: Watzin, 1983; Caffey, 1982).

Whereas the roles of predation and competition in determining structure of both soft- and hard-bottom communities have come under considerable scrutiny in a variety of different habitats (e.g., Connell, 1961; Menge, 1976; Paine, 1966, 1974; Peterson, 1977, 1979; Jackson, 1977, 1979), the part played by recruitment has received much less attention. To understand the dynamics of sublittoral and intertidal communities —— that is, changes in spatial distribution, species composition and size over time —— it is necessary to know both the rate and timing of larval recruitment. The relative importance of larval settlement in relation to other factors that control the distribution of species (e.g., competition and predation) also needs to be understood better.

It has been suggested that the mode of development influences geographic variation as well as species range and that larvae may act as agents of genetic exchange or gene flow between widely separated populations (Gooch, 1975; Scheltema, 1975; Sulkin and Van Heukelem, 1982). More evidence is required to test the relationship of larval dispersal to geographic range and gene flow.

Finally, meroplankton of temperate waters at certain times of the year may constitute a large fraction of the total zooplankton standing crop and

consequently must play a significant but unknown role in the dynamics of the plankton community at such times.

ACKNOWLEDGEMENTS

I am indebted to Dr. Gordon Hendler for his help with the echinoderm literature and to Dr. John Farrington for encouragement in making available the information included in this report. To Amelie I am grateful for help in checking the tables. The production of this report was made possible by funds from the Mellon Foundation.

Table 3. Summary of information available on larval development of common gastropod species in the region of Woods Hole, Massachusetts (excluding shell-less Opisthobranchia)

Species	Mode of development[1]	Larva described[2]	Egg capsule figured	References
Acmaea testudinalis (Müller, 1776)	P	Yes*	None	Kessel, 1964; Thorson, 1946
Acteon punctostriatus (C.B. Adams, 1840)	?	No	No	
Anachis avara (Say, 1822)	P	Yes*	Yes	Scheltema & Scheltema, 1963; A. Scheltema, 1969
Anachis translirata (Ravenel, 1861)	P	Yes*	Yes	A. Scheltema, 1969
Bittium alternatum (Say, 1822)	P	Yes+	No	Thiriot-Quievreaux & Scheltema, 1982
Buccinum undatum L., 1761	D	-	Yes	Thorson, 1946; Abbott, 1954
Busycon canaliculatum (L., 1758)	D	-	Yes	Abbott, 1954, p. 26, Fig. 8; Magalhaes, 1948
Busycon carica (Gmelin, 1790)	D	-	Yes	Abbott, 1954, p. 26, Fig. 8; Magalhaes, 1948
Caecum cooperi S. Smith, 1860	P	No	No	
Caecum pulchellum Stimpson, 1851	P	Yes+	No	Thiriot-Quievreux, 1980, 1983
Cerithiopsis greeni (C. B. Adams, 1839)	P	Yes+	No	Thiriot-Quievreux, 1980, 1983
Cerithiopsis subulata (Montagu, 1808)	P	No	No	
Cingula aculeus Gould, 1841	?	No	No	
Colus pubescens (Verrill, 1882)	?	No	No	
Colus pygmaea (Gould, 1841)	?	No	No	
Colus stimpsoni (Mörch, 1867)	?	No	No	
Crepidula convexa (Say, 1822)	D	-	Yes	Hendler & Frank, 1971
Crepidula fornicata (L., 1767)	P	Yes*	Yes	Werner, 1955
Crepidula plana (Say, 1822)	P	Yes*	No	Thiriot-Quievreux & Scheltema, 1982
Crucibulum striatum (Say, 1826)	?	No	No	
Cylichna alba (Brown, 1827)	?	No	No	
Epitonium rupicola Kurtz, 1860	P	Yes	Yes	McDermott, 1981, only early larva
Eupleura caudata (Say, 1822)	D	-	Yes	Galtsoff, 1964, p. 432
Haminoea solitaria (Say, 1822)	P	Yes*	No	Harrington & Alkon, 1978
Hydrobia spp.	?	No	No	
Lacuna vincta (Montagu, 1803)	P	Yes+	Yes	Lebour, 1937; Thorson, 1946; Fretter & Pilkington, 1970
Littorina littorea (L., 1758)	P	Yes+	Yes	Thorson, 1946; Fretter & Pilkington, 1970
Littorina obtusata (L., 1758)	D	-	Yes	Thorson, 1946
Littorina saxatilis s. l. (Olivi, 1792)	D	-	-	Thorson, 1946; broods young
Lunatia heros (Say, 1822)	P	Yes*	Yes	Dacy, 1965; Giglioli, 1955; Thiriot-Quievreux & Scheltema, 1982
Lunatia triseriata (Say, 1826)	D	-	Yes	Giglioli, 1955
Melampus bidentatus (Say, 1822)	P	Yes*	Yes	Russell-Hunter et al., 1972
Mitrella lunata (Say, 1826)	P	Yes+	No	Thiriot-Quievreux, 1980
Nassarius obsoletus (Say, 1822) [= Ilyanassa]	P	Yes*	Yes	R. Scheltema, 1962
Nassarius trivittatus (Say, 1822)	P	Yes*	Yes	Scheltema & Scheltema, 1965
Nassarius vibex (Say, 1822)	P	Yes*	Yes	R. Scheltema, 1962
Neptunea decemcostata (Say, 1826)	D	-	No	Golikov, 1963; figures egg capsules of congener
Odostomia bisuturalis (Say, 1821) [= Boonea]	P	No	No	Congener described by Thorson, 1946 See: Robertson, 1978 for structure
Odostomia seminuda (C.B. Adams, 1839) [= Boonea]	P	No	No	of spermatophore
Ovatella myosotis (Draparnaud, 1801)	?	No	No	
Polinices duplicatus (Say, 1822)	P	No	Yes	Giglioli, 1955; Hanks, 1960 (no illustrations)
Polinices immaculatus (Totten, 1835)	P	No	No	
Retusa canaliculata (Say, 1822)	P(?)	No	No	Congener described. See: Thorson, 1946
Scilla adamsi (H. C. Lea, 1845)	P	Yes+	No	Thiriot-Quievreaux, 1980
Thais lapillus (L., 1758) [= Nucella]	D	-	Yes	Thorson, 1946; Yonge, 1949
Triphora nigrocincta (C.B. Adams, 1839)	P	Yes+	No	Thiriot-Quievreaux & Scheltema, 1982
Urosalpinx cinerea (Say, 1822)	D	-	Yes	Federighi, 1931; Hancock, 1956
Vermicularia spirata (Philippi, 1836)	P	No	No	Unpublished observation

[1] P = planktonic; D = non-planktonic; (?) = not known.

[2] (*) denotes larvae reared through metamorphosis in the laboratory; (+) denotes larvae identified from plankton by comparison with protoconch or by rearing through metamorphosis.

Table 4. Summary of information available on larval development of the most common bivalve species in the region of Woods Hole, Massachusetts

Species	Mode of development[1]	Larva described[2]	References
Aequipecten irradians (Lamarck, 1819)	P	Yes*	Castagna & Duggan, 1971; Chanley & Andrews, 1971; Loosanoff et al., 1966; Sastry, 1965
Anadara ovalis (Bruguiere, 1789)	P	Yes*+	Jorgensen, 1946 (as A. fasciatum); Rees, 1950
Anadara transversa (Say, 1822)	P	Yes*	Chanley & Andrews, 1971; Loosanoff et al., 1966
Anomia aculeata Müller, 1776	P	Yes+	Sullivan, 1948
Anomia simplex Orbigny, 1845	P	Yes+*	Loosanoff et al., 1966; Sullivan, 1948
Arctica islandica (L., 1758)	Pc	Yes*	Landers, 1976, early larva only; Lutz et al., 1982
Astarte borealis Schumacher, 1817	D	-	Thorson, 1936; field observation
Astarte castanea (Say, 1822)	D	-*	Goodsell et al., in press a,b
Bankia gouldi Bartsch, 1908	P	Yes*	Culliney, 1975
Barnea costata (L., 1758)	P	No	Goodsell et al., in press a
Barnea truncata (Say, 1822)	P	Yes*	Chanley, 1965
Brachidontes recurvus Rafinesque, 1820	P	Yes*	Chanley, 1970
Cardita borealis (Conrad, 1831) [= Cyclocardia]	D	-*	Goodsell et al., in press a
Cerastoderma pinnulatum (Conrad, 1831)	P	Yes+	Sullivan, 1948
Chlamys islandica Müller, 1776	P	No	Ockelman, 1958
Corbula contracta Say, 1822	?	No	
Crassinella mactracea Linsley, 1845	?	No	
Crassostrea virginica (Gmelin, 1792)	P	Yes*	Brooks, 1880; Carriker & Palmer, 1979; Chanley & Andrews, 1971; and others
Cumingia tellinoides Conrad, 1831	P	Yes+	Sullivan, 1948
Ensis directus (Conrad, 1843)	P	Yes*	Chanley & Andrews, 1971; Loosanoff & Davis, 1963; Sullivan, 1948
Gemma gemma (Totten, 1834)	D	Yes+*	Chanley & Andrews, 1971; Sellmer, 1967
Hiatella arctica (L., 1767)	P	Yes+	Jorgensen, 1946; Rees, 1950; Savage & Goldberg, 1976
Hiatella gallicana (Lamarck, 1818)	P	Yes+	Rees, 1950
Laevicardium mortoni (Conrad, 1830)	P	Yes*	Chanley & Andrews, 1971
Lyonsia hyalina (Conrad, 1831)	P	Yes*	Chanley & Castagna, 1966; Chanley & Andrews, 1971
Macoma balthica (L., 1758)	P	Yes+	Sullivan, 1948
Macoma tenta (Say, 1834)	?	No	
Mercenaria mercenaria (L., 1758)	P	Yes*	Chanley & Andrews, 1971; Loosanoff et al., 1966; Sullivan, 1948
Modiolus demissus (Dillwyn, 1817) [= Geukensia]	P	Yes+*	Loosanoff et al., 1966; Sullivan, 1948
Modiolus modiolus (L., 1758)	P	Yes+*	Jorgensen, 1946; Lutz & Hidu, 1979; Rees, 1950; Schweinitz & Lutz, 1976
Mulinia lateralis (Say, 1822)	P	Yes*	Chanley & Andrews, 1971; Loosanoff et al., 1966; Rees, 1950
Musculus niger (Gray, 1824)	?	No	
Mya arenaria L., 1758	P	Yes+*	Chanley & Andrews, 1971; Loosanoff et al., 1966; Savage & Goldberg, 1976; Sullivan, 1948
Mytilus edulis L., 1758	P	Yes+*	Chanley & Andrews, 1971; Jorgensen, 1946; Loosanoff & Davis, 1963; Loosanoff et al., 1966; Lutz & Hidu, 1979; Rees, 1950; Sullivan, 1948; Werner, 1939
Nucula proxima (Say, 1822)	L	Yes*	Drew, 1899
Nucula annulata Hampson, 1971	L	No	Unpublished
Nucula delphinodonta Mighels & Adams, 1842	D	Yes*	Drew, 1899
Pandora gouldiana (Dall, 1886)	P	Yes	Rees, 1950; Sullivan, 1948
Petricola pholadiformis Lamarck, 1818	P	Yes+*	Chanley & Andrews, 1971; Loosanoff et al., 1966; Rees, 1950; Sullivan, 1948
Periploma leanum (Contrad, 1831)	Pc	-*	Goodsell et al., in press a,b
Pitar ("Callocardia") morrhuana (Linsley, 1848)	P	Yes+*	Loosanoff et al., 1966; Sullivan, 1948
Placopecten magellanicus (Gmelin, 1790)	P	Yes+	Culliney, 1974
Siliqua costata (Say, 1822)	?	No	
Solemya velum (Say, 1822)	?	No	Gustafson, 1984 (congener), large demersal egg (unpublished)
Spisula solidissima (Dillwyn, 1817)	P	Yes+*	Chanley & Andrews, 1971; Loosanoff et al., 1966; Rees, 1950; Sullivan, 1948
Tagelus divisus (Spengler, 1794)	P	No	
Tagelus plebeius (Solander, 1786)	P	Yes*	Chanley & Castagna, 1971
Tellina agilis Stimpson, 1857 [= T. tenera Say]	P	Yes+*	Chanley & Andrews, 1971; Sullivan, 1948
Teredo navalis L., 1758	Pb	Yes+*	Chanley & Andrews, 1971; Culliney, 1975; Imai et al., 1950; Jorgensen, 1946; Loosanoff et al., 1966; Sullivan, 1948
Thyasira gouldi (Philippi, 1845)	D	-	Blackwell & Ansell, 1975, field observation
Thyasira trisinuata (Orbigny, 1846)	?	No	
Yoldia limatula (Say, 1831)	L	Yes*	Drew, 1899
Zirfaea crispata (L., 1758)	P	Yes+	Jorgensen, 1946; Rees, 1950; Sullivan, 1948; Werner, 1939

[1] P = planktonic; Pb = planktonic but early stages brooded; Pc = part of development in egg capsule; L = lecithotrophic; D = direct development; ? = not known.

[2] (*) = development observed in laboratory; (+) = larvae described from plankton.

Table 5. Summary of information available on larval development of common decapod and stomatopod crustacean species in the region of Woods Hole, Massachusetts

Species	Larva described[1]	Reference
DECAPODA		
CARIDEA		
Crangon septemspinosus Say, 1818	Yes*	Needler, 1941; Tesmer & Broad, 1964
Hippolyte zostericola (Smith, 1874)	No	Congener described, Shield, 1978
Palaemonetes intermedius Holthuis, 1949	Yes*	Hubschman and Broad, 1974
Palaemonetes pugio Holthuis, 1949	Yes*	Broad, 1957
Palaemonetes vulgaris (Say, 1818)	No	Foxon, 1879a. In older literature this species included P. intermedius, P. pugio and P. vulgaris
ASTACURA		
Homarus americanus Milne-Edwards 1837	Yes*	Herrick, 1896; Factor, 1978
THALASSINIDEA		
Callianassa atlantica (Smith, 1874)	Yes+	Sandifer, 1973a
Naushonia crangonoides Kingsley, 1895	Yes+	Goy and Provenzano, 1978
Upogebia affinis (Say, 1817)	Yes+	Sandifer, 1973b
BRACHYURA		
Callinectes sapidus Rathbun, 1895	Yes*	Costlow & Bookhout, 1959
Cancer borealis Stimpson, 1859	Yes*	Sastry, 1977b
Cancer irroratus Say, 1817	Yes*	Sastry, 1977a
Carcinus maenas (L., 1758)	Yes*	Williams, 1968; Rice & Ingle, 1975
Europanopeus depressus (Smith, 1869)	Yes*	Costlow & Bookhout, 1961a
Heterocrypta granulata (Gibbes, 1849)	No	
Libinia dubia Milne-Edwards, 1834	Yes*	Sandifer & Engel, 1971
Libinia emarginata Leach, 1815	Yes*	Johns & Lang, 1977
Neopanope taxana sayi (Smith, 1869)	Yes*	Chamberlain, 1961; McMahan, 1967
Ovalipes ocellatus (Herbst, 1799)	Yes*	Costlow & Bookhout, 1966
Panopeus herbsti Milne-Edwards, 1834	Yes*	Costlow & Bookhout, 1961b
Pelia mutica (Gibbes, 1850)	No	
Pinnixa chaetopterana Stimpson, 1859	No	Congener; Hyman, 1924a; Foxon, 1879b
Pinnixa cylindrica (Say, 1818)	No	Congener; Hyman, 1924a; Foxon, 1879b
Pinnixa sayana Stimpson, 1860	No	Congener; Hyman, 1924a; Foxon, 1879b
Pinnotheres maculatus Say, 1818	Yes*	Costlow & Bookhout, 1966b
Planes minutus (L., 1758)	Yes+	Hyman, 1924b. Early stage only
Rhithropanopeus harrissi (Gould, 1841)	Yes*	Chamberlain, 1962; Hood, 1962; Lawinski and Pantsch, 1969
Sesarma reticulatum (Say, 1817)	Yes*	Costlow & Bookhout, 1962
Uca minax (Le Conte, 1855)	Yes+	Hyman, 1920; late zoeal stages of the three species of Uca were not distinguished by Hyman; Herrenkind, 1968
Uca pugilator (Bosc, 1801-02)	Yes+	
Uca pugnax (Smith, 1870)	Yes+	
ANOMURA		
Emerita talpoida (Say, 1817)	Yes*	Rees, 1952; Shield, 1973
Pagurus annulipes Say, 1817	Yes*	Nyblade, 1970
Pagurus longicarpus Say, 1817	Yes*	Roberts, 1970
Pagurus pollicaris Say, 1817	Yes*	Nyblade, 1970
Polyonyx macrocheles (Gibbes, 1850)	No	Congener described. Gore 1968; Knight, 1966
STOMATOPODA		
Squilla empusa Say, 1818	Yes+*	Brooks, 1878; Morgan and Provenzano, 1978
Nannosquilla grayi (Chace, 1958) [= Lysiosquilla]	No	

[1] (*) = larva described from laboratory culture; (+) = description from larvae collected in plankton samples.

Table 6. Summary of information available on larval development of the most common cirriped crustacean species in the region of Woods Hole, Massachusetts

Species	Reference to description
Balanus amphitrite niveus Darwin, 1854	*Costlow and Bookhout, 1958
Balanus balanus (L., 1758)	*Barnes and Costlow, 1961; Crisp, 1962b
Balanus crenatus Bruguiere, 1789	+Hertz, 1933; Pyefinch, 1948, 1949
Balanus eburneus Gould, 1841	*Costlow and Bookhout, 1957
Balanus improvisus Darwin, 1854	Buchholz, 1951; Jones, 1954
Balanus balanoides (L., 1767) [= Semibalanus]	Runnström, 1925; Bassindale, 1936; Pyefinch, 1948; Crisp, 1962b; Walley, 1969
Balanus hammeri (Ascanius, 1761)	Crisp, 1962a
Chthamalus fragilis Darwin, 1854	*Lang, 1977, 1979

(*) = larva described from laboratory culture.

+ = Balanus crenatus was grown in mass culture be Hertz, 1933 who described 8 nauplii; Pyefinch, 1949 found only 6 nauplii in the plankton, conforming with other known barnacle species.

Table 7. Summary of information available on larval development of common polychaete species in the region of Woods Hole, Massachusetts

Species[1]	Mode of development[2]	Reference
AMPHARETIDAE (9)		
Melinna cristata (Sars, 1851)	P	Nyholm, 1950; Hutchings, 1973
AMPHINOMIDAE (4)		
Amphinome rostrata (Pallas, 1766)	P	Mikeikovsky, 1961 (as A. pallasi)
APHRODITIDAE (2)		
ARABELLIDAE (4)		
ARENICOLIDAE (3)		
Arenicola cristata Stimpson, 1856	B	Marsden & Lacalli, 1978; Newell, 1949; Okada, 1941
Arenicola marina (Linnaeus, 1758)	B	Newell, 1949; Farke & Berghuis, 1979
CAPITELLIDAE (4)		
Capitella capitata (Fabricius, 1780)	B&P*	Grassle & Grassle, 1976, this is a species complex
Heteromastus filiformis (Claparede, 1864)	P*	Rasmussen, 1956
Notomastus latereus Sars, 1851	P*	Wilson, 1933
CHAETOPTERIDAE (2)		
Chaetopterus variopedatus (Renier, 1804)	P*	Cazaux, 1965; Bhaud, 1966
Spiochaetopterus oculatus Webster, 1879	P	Mileikovsky, 1967; Bhaud, 1966
CIRRATULIDAE (5)		
Cirratulus cirratus (O. F. Müller, 1776)	LD	Okuda, 1946; Stephenson, 1950
DORVILLEIDAE (2)		
Stauronereis rudolphi (Delle Chiaje, 1828)	P*	Richards, 1967
EUNICIDAE (4) (see Richards, 1967; Akesson, 1967)		
EUPHROSINIDAE (3)		
FLABELLIGERIDAE (6)		
GLYCERIDAE (3)		
Glycera capitata Oersted, 1843	P*	Levsky, 1970
Glycera dibranchiata Ehlers, 1868	P	Klawe & Dickie, 1957; Simpson, 1962
GONIADIDAE (3)		

HESIONIDAE (6)		
Microphthalmus aberrans (Webster & Benedict, 1887)	P	Westheide, 1967
Nereimyra punctata (O. F. Müller, 1776)	P	Rasmussen, 1973
LUMBRINERIDAE (4) (see Richards, 1967)		
MAGELONIDAE (1)		
Magelona rosea Moore, 1907	P*	Wilson, 1982 describes congeners
MALDANIDAE (13)		
Clymenella torquata (Leidy, 1855)	Ld	Newell, 1951
NEPHYTIDAE (6)		
Nephtys caeca (Fabricius, 1780)	P	Thorson, 1946
Nephtys ciliata (O. F. Müller, 1789)	P	Thorson, 1946
NEREIDAE (7)		
Nereis (Neanthes) succinea (Frey & Leuckart, 1847)	P	Banse, 1975; Rasmussen, 1973
N. (Neanthes) virens Sars, 1835	P(?)	Bass & Brafield, 1972; Sveshnikov, 1960
N. (Nereis) pelagica L., 1758	P*	Wilson, 1932a
Platynereis dumerilii megalops (Verrill, 1874)	P	Hempelmann, 1911; Just, 1922
ONUPHIDAE (6)		
Diopatra cuprea (Bosc, 1802)	P	Allen, 1959
OPHELIIDAE (4)		
Ophelia bicornis Savigny, 1818	P*	Wilson, 1948
ORBINIIDAE (6)		
Scoloplos fragilis (Verrill, 1873)	P	Anderson, 1961
Scoloplos robustus (Verrill, 1873)	P*	Horn & Bookhout, 1950
OWENIIDAE (2)		
Owenia fusiformis Delle Chiaje, 1844	P*	Wilson, 1932b
PARAONIDAE (4)		
PECTINARIIDAE (3)		
PHYLLODOCIDAE (11)		
Eteone longa (Fabricius, 1780)	P	Sveshnikov, 1967; Rasmussen, 1956; Thorson, 1946
Eulalia viridis (L., 1767)	P	Meyer, 1938; Olive, 1975
Phyllodoce groenlandica Oersted, 1842	P	Thorson, 1946
Phyllodoce maculata (L., 1767)	P	Thorson, 1946
POLYNOIDAE (15)		
Gattyana cirrosa (Pallas, 1766)	P	Thorson, 1946
Harmothoe imbricata (L., 1767)	P*	Rassmussen, 1956; Sveshnikov, 1967; Holborrow, 1969
Harmothoe fragilis Moore, 1910	P	Sveshnikov, 1967
Lepidonotus squamatus (L., 1758)	P	Thorson, 1946
SABELLARIIDAE (1)		
SABELLIDAE (7)		
Fabricia sabella (Ehrenberg, 1837)	B	Lewis, 1961
SCALIBREGMIDAE (2)		
SERPULIDAE (7)		
Hydroides dianthus (Verrill, 1873)	P*	Scheltema et al., 1981
Spirorbis borealis Daudin, 1800	Lp	Fewkes, 1885
SIGALIONIDAE (6)		
Pholoe minuta (Fabricius, 1780)	P	Sveshnikov, 1967; Thorson, 1946
SPIONIDAE (13)		
Laonice cirrata (Sars, 1851)	P	Hannerz, 1956
Polydora ciliata (Johnston, 1838)	P*	Wilson, 1928; Hannerz, 1956; Dorsett, 1961
Polydora commensalis Andrews, 1891	P*	Hatfield, 1965; Blake, 1969
Polydora ligni Webster, 1879	P*	Blake, 1969; Orth, 1971; Hannerz, 1956
Prionospio steenstrupi Malmgren, 1867	P	Hannerz, 1956
Scolecolepides viridis (Verrill, 1873)	P*	George, 1966
Scolelepis squamata (O. F. Müller, 1789)	P	Dean & Hatfield, 1963 (as Nerine agilis); Joyner, 1962 (as N. cirratulus); Hannerz, 1956 (as N. cirratulus)
Spio filicornis (O. F. Müller, 1776)	P*	Thorson, 1946; Hannerz, 1956
Spio setosa Verrill, 1873	B&P	Simon, 1967, 1968
Spiophanes bombyx (Claparede, 1870)	P	Thorson, 1946; Hannerz, 1956; Smidt, 1951
Streblospio benedicti Webster, 1879	P*	Dean, 1965

STERNASPIDAE (1)		
Sternaspis scutata (Renier, 1807)	P	Vejdovsky, 1882; Child, 1900
SYLLIDAE : AUTOLYTINAE (6)		
Autolytus fasciatus (Bosc, 1802)	Pb	Allen, 1964
Autolytus prismaticus (Fabricius, 1780)	B&Ld	Thorson, 1946; Sveshnikov, 1967
Autolytus prolifer (O. F. Müller, 1788)	B&Ld	Okada, 1929
SYLLIDAE : EUSYLLINAE (6)		
Sphaerosyllis erinaceus Claparede, 1863	B	Cazaux, 1972
SYLLIDAE : EXOGONINAE (7)		
SYLLIDAE : SYLLINAE (3)		
TEREBELLIDAE (19)		
Amphitrite ornata (Leidy, 1855)	P	Mead, 1897
Loimia medusa (Savigny, 1818)	P*	Wilson, 1928

[1]Since there are 221 species of "common" polychaetes listed, only those for which information is available are included in the body of the table. The figure in parentheses after each family gives the number of species listed under that family in the **WOODS HOLE KEYS**. Species for which no life-history information was found are listed in Appendix II. The names used throughout the table are those used by M. Pettibone in constructing the **KEY**. Usage may vary from that of other authors.

[2]There is uncertainty in some instances where references conflict. Such disagreement may be due to misidentification or possibly poecilogony. B = brooded; P = planktonic; Pb = early stages brooded followed by planktonic stage; D = direct, non-planktonic development; Lp = lecithotrophic planktonic; Ld = lecithotrophic demersal; (*) = reared in laboratory culture.

Table 8. Summary of information available on larval development of common echinoderm species in the region of Woods Hole, Massachusetts

Species	Mode of development[1]	Larva described	References[4]
ASTEROIDEA			
Asterias forbesi (Desor, 1848)	P	Yes[3]	Mead, 1900
Asterias vulgaris Verrill, 1866[2]	P	Yes[3]	Field, 1893; Gemmill, 1914
Henricia sanguinolenta (O. F. Müller, 1776)	D	-	Sars, 1844
OPHIUROIDEA			
Amphipholis squamata (Delle Chiaje, 1828) [= Axiognathus squamatus]	D	-	Coe, 1912; Fell, 1946; Hendler, 1975
Ophioderm brevispina (Say, 1825)	P	Yes	Grave, 1899, 1903
Ophiopholis aculeata (Linnaeus, 1767)	P	Yes	Coe, 1912; Olsen, 1942
ECHINOIDEA			
Arbacia punctulata (Lamarck, 1816)	P	Yes	Coe; 1912; Harvey, 1956
Echinarachnius parma (Lamarck, 1816)	P	Yes	Fewkes, 1886; Vannucci, 1961
Strongylocentrotus drobachiensis (O. F. Müller, 1776)	P	Yes	Stephens, 1972
HOLOTHUROIDEA			
Cucumaria pulcherrima (Ayres, 1854) [= Pentamera]	?	No	
Leptosynapta roseola (Verrill, 1873) [= Epitomapta]	P	No	Costello et al., 1957
Leptosynapta tenuis (Ayres, 1851)	P	No	Costello et al., 1957
Thyone briareus (Lesueur, 1824)	D	-	Oshima, 1925

[1] P = planktonic, L = non-feeding, short planktonic life; D = non-planktonic

[2] Known in the eastern Atlantic under the name Asterias rubens.

[3] Even though these two species frequently have been reared, no illustrations of the larvae appear to have been published that would allow identification from the plankton.

[4] Only the figures of Ophiopholis aculeata and Strongylocentrotus drobachiensis larvae may be useful in identifying larvae from plankton samples. An example of a useful key to echinopluteiz see L. Fenaux (1969) Les echinopluteus de la Mediterranee. Bull. Instit. Oceanogr. (Monaco) 68 (1394), 28 pp.

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APPENDIX I

BIBLIOGRAPHY OF REFERENCES IN TABLES 3 TO 8

APPENDIX I

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APPENDIX II

COMMON POLYCHAETE SPECIES FOR WHICH LIFE HISTORY DATA ARE LACKING

AMPHARETIDAE:

Amage auricula Malmgren, 1866
Ampharete arctica Malmgren, 1866
Ampharete acutifroms (Grube, 1860)
Amphicteis gunneri (Sars, 1835)
Asabellides oculata (Webster, 1879)
Hypaniola grayi Pettibone, 1953
Samytha sexcirrata (Sars, 1856)
Samythella elongata Verrill, 1873

AMPHINOMIDAE:

Hipponoe quadichaudi Audouin & Milne Edwards, 1830
Paramphinome pulchella Sars, 1872
Pareurythoe borealis (Sars, 1862)

APHRODITIDAE:

Aphrodita hastata Moore, 1905
Laetmatonice filicornis Kinberg, 1855

ARABELLIDAE:

Arabella iricolor (Montagu, 1804)
Drilonereis longa Webster, 1879
Drilonereis magna Webster & Benedict, 1887
Notocirrus spiniferus (Moore, 1906)

ARENICOLIDAE:

Arenicola brasiliensis Nonato, 1958

CAPITELLIDAE:

Notomastus luridus Verrill, 1873

CIRRATULIDAE:

Chaetozone setosa Malmgren, 1867
Cirratulus grandis Verrill, 1873
Dodecaceria coralii (Leidy, 1855)
Tharyx acutus Webster & Benedict, 1887

DORVILLEIDAE:

Staurocereis caecus (Webster & Benedict, 1884)

EUNICIDAE:

Eunice norvegica (L.,, 1767)
Eunice pennata (O. F. Müller, 1776)
Marphysa bellii (Audouin & M. Edwards, 1833)
Marphysa sanguinea (Montagu, 1815)

EUPHROSINIDAE:

Euphrosine cirrata Sars, 1862
Euphrosine borealis Oersted, 1843
Euphrosine armadillo Sars, 1851

FLABELLIGERIDAE:

Brada granosa Stimpson, 1854
Brada villosa (Rathke, 1843)
Diplocirrus hirsutus (Hansen, 1879)
Flabelligera affinis Sars, 1829
Pherusa affinis (Leidy, 1855)
Pherusa plumosa (Müller, 1776)

GLYCERIDAE:

Glycera americana Leidy, 1855

GONIADIDAE:

Goniada maculata Oersted, 1843
Goniadella gracilis (Verrill, 1873)
Ophioglycera gigantea Verrill, 1885

HESIONIDAE:

Gyptis vittata Webster and Benedict, 1887
Microphthalmus sczelkowii Mecznikow, 1865
Parahesione luteola (Webster, 1880)
Podarke obscura Verrill, 1873

LUMBRINERIDAE:

Lumbrineris acuta (Verrill, 1875)
Lumbrineris fragilis (O. F. Müller, 1776)
Lumbrineris tenuis (Verrill, 1873)
Ninoe nigripes Verrill, 1873

MALDANIDAE:

Asychis biceps (Sars, 1861)
Axiothella catenata (Malmgren, 1856)

Clymenella zonalis (Verrill, 1874)
Leiochone dispar (Verrill, 1873)
Maldane sarsi Malmgren, 1865
Maldanopsis elongata (Verrill, 1873)
Nicomache lumbricalis (Fabricius, 1780)
Petaloproctus tenuis (Theel, 1879)
Praxillella gracilis (Sars, 1861)
Praxillella ornata Verrill, 1880
Praxillella ornata Verrill, 1880
Rhodine loveni Malmgren, 1865

NEPHYTIDAE:

Aglaophamus circinata (Verrill, 1874)
Nephtys bucera Ehlers, 1868
Nephtys incisa Malmgren, 1865
Nephtys picta Ehlers, 1868

NEREIDAE:

Lycastopsis pontica (Bobretzky, 1872)
Nereis (Neanthes) arenaceodonta Moore, 1903
Nereis (Nereis) grayi Pettibone, 1956

ONUPHIDAE:

Hyalinoecia tubicola (O. F. Müller, 1776)
Onuphis (Nothria) conchylega Sars, 1835
Onuphis (Nothria) opalina (Verrill, 1873)
Onuphis (Onuphis) eremita Audouin & M. Edwards, 1833
Onuphis (Onuphis) quadricuspis Sars, 1872

OPHELIIDAE:

Ammotrypane aulogaster Rathke, 1843
Ophelia denticulata Verrill, 1875
Travisia carnea Verrill, 1873

ORBINIIDAE:

Naineris quadricuspida (Fabricius, 1780)
Orbinia ornata (Verrill, 1873)
Scoloplos acutus (Verrill, 1873)
Scoloplos riseri Pettibone, 1957

OWENIIDAE:

Myriochele heeri Malmgren, 1867

PARAONIDAE:

Aricidea jeffreysii (McIntosh, 1879)
Aricidea quadrilobata Webster & Benedict, 1887
Paraonis fulgens (Levinsen, 1883)
Paraonis gracilis (Tauber, 1879)

PECTINARIIDAE:

Pectinaria (Cistenides) gouldii (Verrill, 1873)
Pectinaria granulata (L., 1767)
Pectinaria hyperborea (Malmgren, 1866)

PHYLLODOCIDAE:

Eteone lactea Claparede, 1868
Eulalia bilineata (Johnston, 1840)
Eumida sauguinea (Oersted, 1843)
Notophyllum americanum Verrill, 1885
Paranaitis speciosa (Webster, 1880)
Phyllodoce (Anaitides) arenae Webster, 1879
Phyllodoce (Anaitides) mucosa Oersted, 1843

POLYNOIDAE:

Alentiana aurantiaca (Verrill, 1885)
Antinoella angusta (Verrill, 1874)
Arcteobia anticostiensis (McIntosh, 1874)
Enipo gracilis Verrill, 1874
Gattyana amondseni (Malmgren, 1867)
Harmothoe (Eunoe) nodosa (Sars, 1860)
Harmothoe (Eunoe) oerstedi (Malmgren, 1865)
Harmothoe (Eunoe) spinulosa (Verrill, 1870)
Harmothoe (Lagisca) extenuata (Grube, 1840)
Lepidametria commensalis Webster, 1879
Lepidonotus sublevis Verrill, 1873

SABELLARIIDAE:

Sabellaria vulgaris Verrill, 1873

SABELLIDAE:

Chone infundibuliformis Kröyer, 1856
Euchone rubrocincta (Sars, 1861)
Myxicola infundibulum (Renier, 1804)
Potamilla neglecta (Sars, 1851)
Potamilla reniformis (L., 1788)
Sabella crassicornis Sars, 1851
Sabella microphthalma Verrill, 1873

SCALIBREGMIDAE:

Scalibregma inflatum Rathke, 1843
Polyphysia crassa (Oersted, 1843)

SERPULIDAE:

Filograna implexa Berkeley, 1828
Protula tubularia (Montagu, 1803)
Spirorbis (Dexiospira) spirillum (L., 1758)
Spirorbis (Laeospira) granulata (L., 1767)
Spirorbis (Paradexiospira) violaceus Levinsen, 1883

SIGALIONIDAE:

Leanira hystricus Ehlers, 1875
Leanira tetragona (Oersted, 1945)
Sigalion arenicola Verrill, 1879
Sthenelais boa (Johnston, 1873)
Sthenelais limicola (Ehlers, 1864)

SPIONIDAE:

Dispio uncinata Hartman, 1951
Prionospio heterobranchia Moore, 1907

SYLLIDAE: AUTOLYTINAE:

Autolytus alexandri Malmgren, 1867
Autolytus cornutus A. Aggassiz, 1863
Autolytus emertoni Verrill, 1881

SYLLIDAE: EUSYLLINAE:

Amblyosyllis finmarchica (Malmgren, 1867)
Eusyllis blomstrandi Malmgren, 1867
Eusyllis lamelligera Marion and Bobretsky
Odontosyllis fulgurans Claparede, 1864
Parapionosyllis longicirrata (Webster and Benedict, 1884)
Syllides longocirrata Oersted, 1845
Syllides setosa Verrill, 1882

SYLLIDAE: EXOGONINAE:

Brania clavata (Claparede, 1863)
Brania wellfleetensis Pettibone, 1956
Exogone dispar (Webster, 1879)
Exogone hebes (Webster & Benedict, 1884)
Exogone verugera (Claparede, 1868)

SYLLIDAE: SYLLINAE

Syllis cornuta Rathke, 1843
Syllis gracilis Grube, 1840
Syllis spongiphila Verrill, 1885

TEREBELLIDAE:

Amphitrite affinis Malmgren, 1866
Amphitrite cirrata O. F. Müller, 1771
Amphitrite johnstoni Malmgren, 1866
Enoplobranchus sanguineus (Verrill, 1873)
Lysilla alba Webster, 1879
Nicolea venustula (Montagu, 1818)
Pista cristata (O. F. Müller, 1776)
Pista maculata (Dalyell, 1853)
Pista palmata (Verrill, 1873)
Polycirrus eximius (Leidy, 1855)
Polycirrus medusa Grube, 1850
Polycirrus phosphoreus Verrill, 1880
Streblosoma spiralis (Verrill, 1874)
Terebella lapidaria (L., 1767)
Terebellides stroemi Sars, 1835
Thelepus cincinnatus (Fabricius, 1780)
Trichobranchus glacialis Malmgren, 1866

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16. Abstract (Limit: 200 words)

This report summarizes what is known about the early development of 380 of the most common invertebrate species found near Woods Hole, Massachusetts and gives bibliographic sources for the descriptions of 98 planktonic larval forms, including Gastropoda, Bivalvia, Decapoda, Stomatopoda, Cirripedia, Polychaeta, and Echinodermata. Many of the existing published descriptions of planktonic larvae are inadequate for their identification in samples taken from natural populations. Although the life-histories of less than one-half of the most common benthic invertebrates from the region of Woods Hole are presently known, such data are important for both ecological studies and for understanding the dynamics of benthic communities.

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